




# Arachnoid Cysts of the Internal Auditory Canal: Multiplanar Magnetic Resonance Imaging With Audio-Vestibular Correlates

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**Objectives/Hypothesis:** To investigate prevalence, radiological characteristics, and functional correlates of arachnoid cysts (AC) of the internal auditory canal (IAC) region, including associations of nerve compression with auditory/vestibular symptoms and asymmetrical audiogram or vestibular testing.

**Study Design:** Retrospective study.

**Methods:** T2-weighted magnetic resonance imaging (MRI) studies of IACs were retrospectively analyzed from 1247 patients with asymmetric auditory or vestibular symptoms. Patients with radiological findings of AC of the IAC were identified. Multiplanar analysis was used to analyze cyst position in the IAC and assess nerve displacement or compression. Size, position, and presence of nerve compression were correlated with symptoms.

**Results:** Twenty-four patients had a cyst in the middle or fundus in the IAC. Diameter ( $P = .04$ ) and position ( $P = .002$ ) of AC were associated with symptoms. Sagittal analyses identified displacement versus compression ( $P = .003$ ) more reliably than axial imaging. Symptom laterality was associated with the site of radiological abnormality. Vestibular nerve compression was associated with vertigo ( $P = .0001$ ), and cochlear nerve compression was associated with auditory symptoms ( $P < .0001$ ).

**Conclusions:** In a retrospective series of patients undergoing MRI of IACs for asymmetric auditory or vestibular impairment, clinical symptom profile correlated with blinded assessment of IAC lesions.

**Key Words:** Magnetic resonance imaging, arachnoid cyst, cochlear nerve, hearing loss, vertigo.

**Level of Evidence:** 4

*Laryngoscope*, 131:2323–2331, 2021

## INTRODUCTION

Arachnoid cysts (AC) are cerebrospinal fluid-filled sacs, covered by a membrane of arachnoidal cells that are thought to arise from a congenital split of the arachnoid layer or trauma.<sup>1</sup> AC have received surprisingly little attention in otolaryngology—head and neck surgery; yet, they represent the most common type of brain cyst, and approximately 11% of AC occur in the cerebellopontine angle.<sup>1</sup> Although many AC are asymptomatic, cysts that occur within bony confines, such as the

internal auditory canal (IAC) may have increased risk of compressive symptoms.<sup>2–4</sup> Literature investigating AC of the IAC is scarce, but available data have suggested associations with sensorineural hearing loss (SNHL),<sup>1–3</sup> unilateral tinnitus,<sup>5,6</sup> vertigo,<sup>7,8</sup> or temporary facial palsy<sup>9,10</sup> similar to cystic variants of schwannoma.<sup>11</sup> Diagnosis most commonly follows abnormal auditory or vestibular testing<sup>10</sup> and magnetic resonance imaging (MRI) with IAC protocol.<sup>12</sup> Gadolinium-based contrast agents facilitate differentiation of AC from tumors<sup>12</sup> although gadolinium may induce allergic reactions in predisposed individuals.<sup>13,14</sup>

Radiological assessment of AC is challenging due to the thin arachnoid membrane and the small, complex anatomy of the IAC. Multiplanar reconstruction (MPR) may increase spatial resolution. MPR is particularly useful for delineating compressive phenomena, such as mass effects exerted on adjacent neural structures.<sup>15</sup> We previously reported on this approach, demonstrating utility of MPR for characterizing vascular loops features (e.g., position, contact with nerve, and vessel caliber). MPR findings have previously been correlated with auditory and vestibular symptoms<sup>16</sup> and discriminate benign nerve displacement from compressive nerve injury for surgical planning.<sup>17</sup> We hypothesized that site-specific neural compression of cochlear or vestibular nerves in the IAC would correlate with clinical symptoms. We analyzed size and location of cysts, the radiological features and patterns of cranial nerve displacement, and presence of nerve compression.

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Additional supporting information may be found in the online version of this article.

Editor's Note: This Manuscript was accepted for publication on June 12, 2021.

The authors have no funding, financial relationships, or conflicts of interest to disclose.

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DOI: 10.1002/lary.29699

## MATERIALS AND METHODS

All study procedures were performed in strict accordance with institutional research board (ID: 0027032019), and Helsinki declaration. This project was conducted in a tertiary referral University hospital. All MRIs of IACs acquired from 1247 sequential studies from November 2019 to October 2020 were analyzed. MRIs were performed with and without gadolinium, using a Philips Gyroscan Achieva (Philips Achieva-XR, Netherlands 2010) by using 3D-DRIVE and 2D-T2WI sequences.

Table S1 summarizes the protocol for MRI acquisition.

Patient *inclusion* criteria were: asymmetric hearing loss, tinnitus, vertigo, or a combination of these symptoms. *Exclusion* criteria were: known otoneurologic conditions; Cerebellum Pontine Angle tumors; inner, middle or external ear pathologies (e.g., Ménière's disease); major neurological diseases (Alzheimer's disease, Parkinson's disease, Multiple Sclerosis, stroke) or diabetes; and history of otologic surgery or cancer treated with radiotherapy or chemotherapy. Data on age, gender, symptom(s), symptom(s) side, pure tone audiometry test results, and vestibular tests results were collected. Data were corroborated with the indication for procedure based on audiogram or vestibular testing. Analyses of AC of the IAC were independently performed by two senior neuroradiologists blinded to clinical data. A third neuroradiologist adjudicated disagreements. 3D-DRIVE and 2D-T2WI axial sequences were analyzed (Fig. 1A,B). If arachnoid cyst was identified, sagittal view 2D-T2WI was analyzed for nerve displacement and compression (Fig. 2A,B).

The images were initially analyzed on axial view and classified as “absent,” “consistent,” or “indeterminate”

depending on whether an arachnoid cyst was clearly absent, deemed present, or equivocal/possibly an artifact (Fig. 1A,B), respectively. Only the images verified as “consistent” on a second round of analysis by both neuroradiologists were analyzed via MPR (hereafter “arachnoid cysts”) for nerve displacement and displacement and compression. In the absence of a control group, we used the healthy side (without cyst) as control.

### Multiplanar Analyses

**AXIAL views analysis (3D-DRIVE and 2D-T2WI).** Axial analysis on AC assessed three parameters: *diameter* of arachnoid cyst, *location* of arachnoid cyst along the length of the IAC, and evidence for *nerve displacement or nerve displacement and compression*.

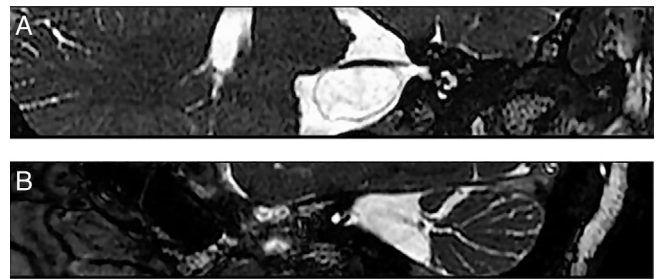


Fig. 2. A, Axial view shows in detail a case of arachnoid cyst of the CPA jutting in the internal auditory canal (IAC). B, Sagittal view of the IAC allows to complete the multiplanar analysis.

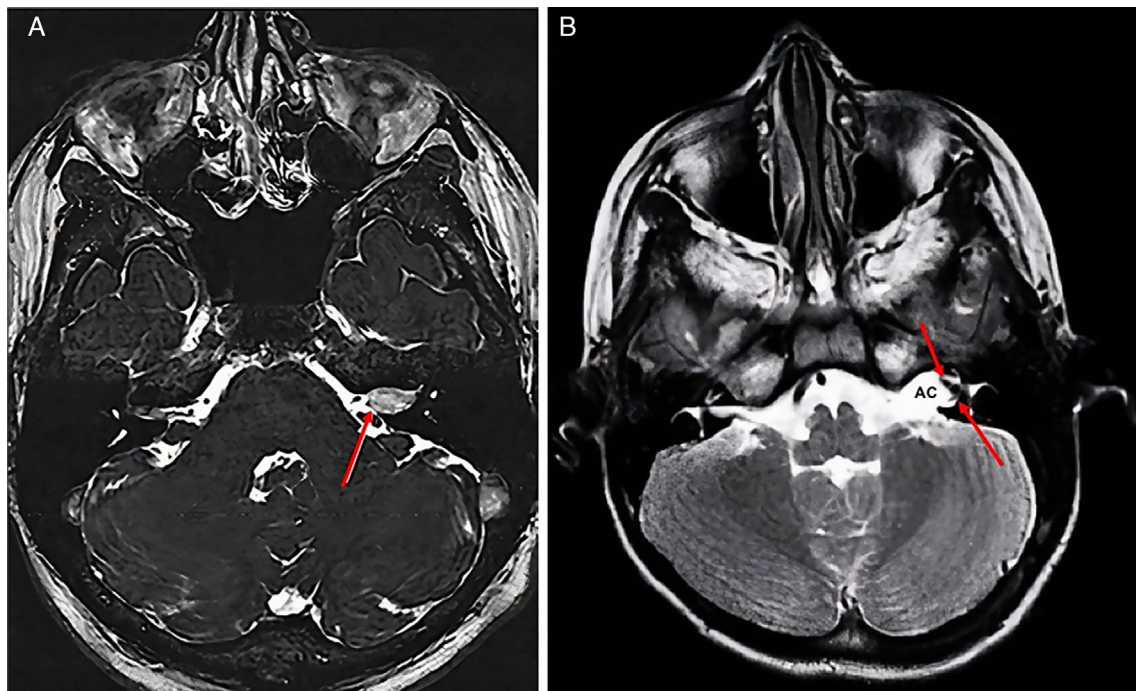


Fig. 1. The images show the magnetic resonance imaging (MRI) sequences used to perform the multiplanar analysis. A, Axial 3D-Drive image; the red arrow shows the arachnoid cyst in the internal auditory canal (IAC). B, 2D-T2WI image which shows the arachnoid cyst (AC) in the IAC and the compression and displacement that the mass on the nerves (cochlear and vestibular) as show by the red arrows. [Color figure can be viewed in the online issue, which is available at [www.laryngoscope.com](http://www.laryngoscope.com).]

For diameter, the largest diameter on axial view was measured. For location, the AC of the IAC were classified as either Porus Acusticus (PA), middle, or fundus based on anatomic regions of the IAC. For assessment of nerve displacement or compression, comparisons were made using the patient's contralateral ear as control (Fig. 3A). If the nerves ran parallel to each other, were straight, and were in the center of the IAC (Fig. 3A), the position was labeled as "normal"; if nerves were off-center or did not run parallel and straight, the designation was "nerve displacement"; and if nerves were attenuated or deformed against the bony wall (Fig. 3B,C) the designation was "nerve displacement and compression." Analysis of displacement and displacement and compression were designated for paired cochlear and facial nerves posteriorly and paired superior and inferior vestibular nerves anteriorly; sub-analysis of individual nerves within their respective quadrants was not performed.

**SAGITTAL views analysis (2D-T2WI).** Analysis of AC of the IAC on sagittal sections allowed for verification of previously noted axial parameters, assessment of *position relative to nerve bundle* (displacement), and more in-depth characterization of compressive characteristics (displacement and compression) (Fig. 4A,B), again using the contralateral ear as a control. First, the paired cochlear/facial nerves and paired inferior/superior vestibular nerves were identified (Fig. 4A) and inspected along their course from the PA to the fundus of the IAC, verifying location of the arachnoid cyst within the IAC (as identified in the axial views analysis). Next, assessment of position of the arachnoid cyst relative to the nerves bundle was determined as previously described.<sup>7</sup>

Briefly, if the arachnoid cyst displaced one or more nerves in the IAC and increased the distance between nerves, the arachnoid cyst was classified as central; in contrast, if an arachnoid cyst displaced and compressed all nerve components against the IAC internal wall, it was classified as lateral. Next, nerve deformation associated with the arachnoid cyst was determined. A round shape was interpreted as "nerve compression absent" (Fig. 4A), whereas deformation to an oval, crescent, or rectangular shape was interpreted as "nerve compression present" (Fig. 4B); in this analysis, we did not consider nerve displacement, but only compression.

### Statistical Analysis

Statistical analysis assumed the null hypothesis that AC of IAC had no effects on hearing, balance, or tinnitus, with symptoms equally distributed on sides with and without arachnoid cyst. Using the clinical and radiological data, the prevalence of each symptom was calculated, and Chi-square ( $\chi^2$ ) was used to assess for association between IAC arachnoid cyst and ipsilateral symptoms. Point-biserial correlation (PBC) was then calculated to measure association between measured arachnoid cyst diameter and presence of symptoms. Criteria met for arachnoid cyst versus arachnoid cyst absent/indeterminate was designated as a binary variable. Symptoms were also defined as binary variables, regarded as present if the patient reported one or more symptoms. Arachnoid cyst diameter was a continuous variable. Chi-square ( $\chi^2$ ) test was also used to assess the association between arachnoid cyst location along

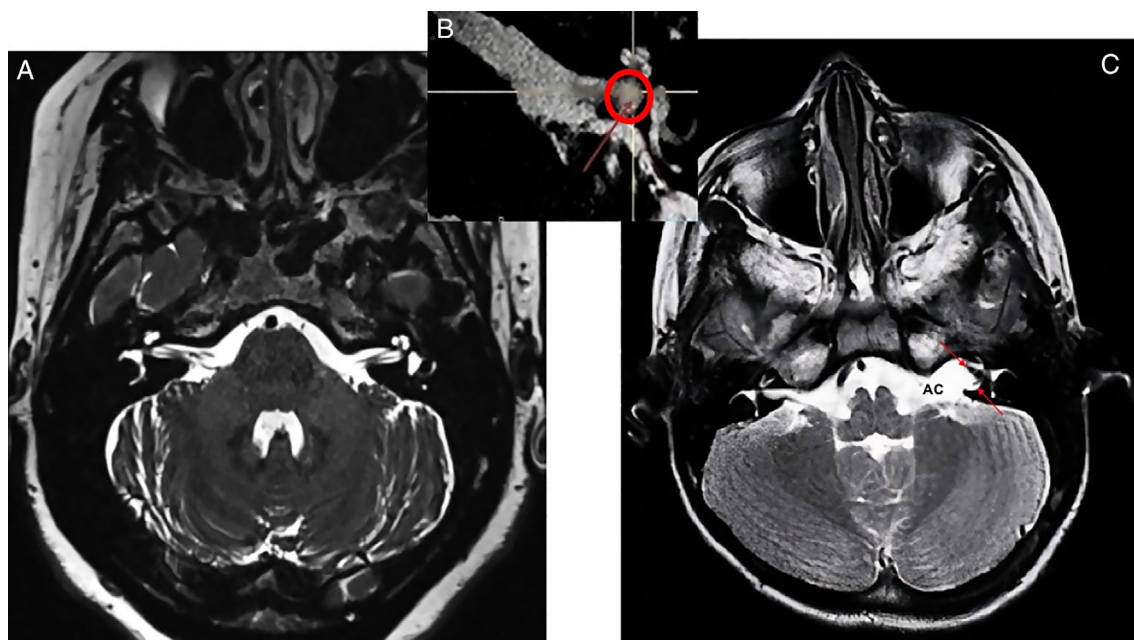


Fig. 3. Axial views. A, 3D-DRIVE. Nerves with normal course in the internal auditory canal (IAC). B, The red arrow shows an arachnoid cyst (red circled) that is located laterally in the fundus of the IAC and compresses nerves; the hypointense lesion visible in the medial and posterior section of the porus acusticus internus is an magnetic resonance imaging artifact. C, 2D T2WI. The nerve bundle is displaced and compressed by the arachnoid cyst in the IAC as showed in the T2 weighted image. [Color figure can be viewed in the online issue, which is available at [www.laryngoscope.com](http://www.laryngoscope.com).]

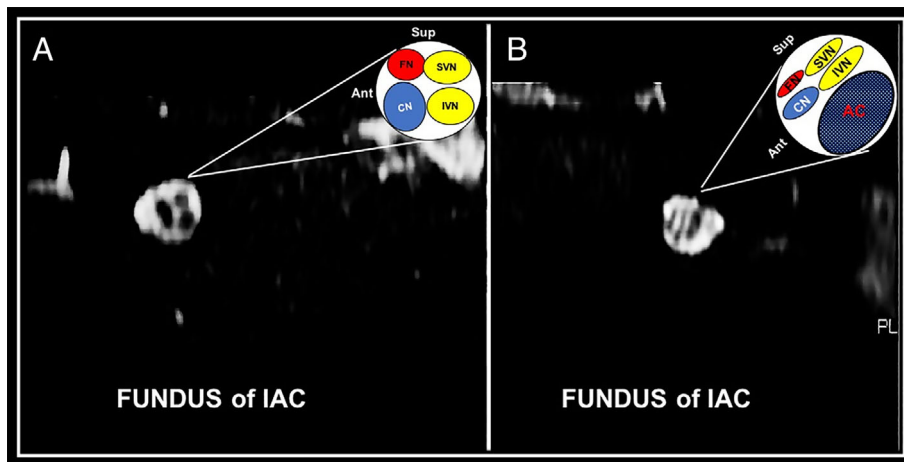


Fig. 4. Details of internal auditory canal (IAC). Sagittal views. A, IAC with normal anatomy. The cross-sectional shape of the nerve is round, and the nerves reside in their natural position. The drawing shows the position of the nerves (CN = cochlear nerve; FN = facial nerve; IFN = inferior vestibular nerve; SVN = superior vestibular nerve) B, arachnoid cyst in the IAC that compresses nerves of the IAC. The shape of the compressed nerve is rectangular. The drawing shows that the four nerves (facial, cochlea, superior vestibular and inferior vestibular) are compressed anterior-superiorly due to arachnoid cyst located in the inferior part of the IAC; so they are displaced in the anterior part of the IAC and compressed under the wall. Facial, cochlear, and vestibular nerves are shown in red, blue, and yellow respectively. [Color figure can be viewed in the online issue, which is available at [www.laryngoscope.com](http://www.laryngoscope.com).]

Table I.  
Description of Patient Symptoms and Arachnoid Cysts Side and Position.

Symptom	Side of the Arachnoid Cyst	Position in the IAC	Nerve Involved
Vertigo	Lf	Middle	Vestibular
Unilateral tinnitus and vertigo	Rh	Fundus	Cochlear and vestibular
Fullness	Lf	PA	None
SNHL Lf	Lf	Fundus	Cochlear and vestibular
Vertigo and ataxia	Rh	PA	None
Vertigo	Lf	Fundus	Vestibular
Asymmetric SNHL	Rh	Fundus	Cochlear and vestibular
Asymmetric SNHL and vertigo	Rh	Middle	Cochlear and vestibular
Asymptomatic	Lf	PA	None
Vertigo	Lf	Middle	Vestibular
Unilateral pulsatile tinnitus	Lf	Fundus	Vestibular
Unilateral tinnitus and vertigo	Rh	Middle	Cochlear and vestibular
Pulsatile tinnitus	Rh	Fundus	Cochlear and vestibular
Pulsatile tinnitus	Rh	Fundus	Cochlear and vestibular
Vertigo	Rh	Middle	Vestibular
Asymptomatic	Rh and Lf	Fundus	Vestibular
Asymmetric SNHL	Rh	Fundus	Cochlear and vestibular
Vertigo	Lf	Middle	Vestibular
Vertigo	Rh	Fundus	Vestibular
Asymmetric SNHL and tinnitus	Rh	Fundus	Cochlear and vestibular
Tinnitus and vertigo	Rh	PA	Vestibular
Asymmetric SNHL	Lf	Middle	Cochlear and vestibular
Asymptomatic	Lf	Middle	Vestibular
Asymmetric SNHL	Lf	Fundus	Cochlear and vestibular

Bil = bilateral; IAC = internal auditory canal; Lf = left side; PA = porus acusticus; Rh = right side; SNHL = sensorineural hearing loss.

the length of the IAC and symptoms. Arachnoid cyst location (PA, middle or fundus) and symptoms (presence or absence) were categorical variables. Chi-square

( $\chi^2$ ) test was also used to compare how often nerve compression was detected by radiologists when analyzing axial views versus sagittal views on MRI.

Spearman correlations were calculated to analyze whether radiological findings of nerve compression (paired cochlear-facial nerves or paired inferior/superior vestibular nerves) on sagittal view analysis were correlated to reported auditory or vestibular impairment. Presence or absence of nerve compression and symptoms of auditory or vestibular impairment were categorical variables. We calculated the correlation between 1) compression of the paired cochlear/facial nerves and auditory symptoms (SNHL and tinnitus); 2) compression of the paired inferior/superior vestibular nerves and vertigo; 3) compression of the cochlear/facial nerves and multiple symptoms; and 4) compression of the inferior/superior vestibular nerves and multiple symptoms. For all tests, significance level was set to 0.05. All statistical tests were performed using Stata<sup>®</sup>.

## RESULTS

MRIs were initially labeled “consistent” or “indefinite” in 156 out of the 1247 patients. The MRIs of 24 patients were verified as “consistent” by both neuroradiologists and further analyzed via MPR.

### Axial Views Analysis

Arachnoid cyst of the IAC was present in 24 of 1247 patients (1.9% of patients; 10 females and 14 males; mean age: 41 years [SD: 12.6]), i.e., their MRI was verified as “consistent” by both neuroradiologists. AC were located in the right IAC in 12 patients (50% of patients with

arachnoid cyst), in the left IAC in 11 patients (45.8%), and bilateral in one patient (4.2%). Arachnoid cyst was located in the PA in 4 patients (16.6% of patients with arachnoid cyst), in middle of the IAC in 8 patients (33.4%), and in the fundus of the IAC in 12 patients (50%) (see Table I) (Fig. 5A). Mean arachnoid cyst diameter was 9.9 mm (SD: 6) (Fig. 5B). Only 1 of 4 AC in the PA caused nerve displacement, affecting cochlear, facial, and vestibular nerves (Fig. 6A,B). Among the AC located in the middle of the IAC (Fig. 6A,B), 5 displaced cochlear and facial nerve (62.5% of AC in this location) and 3 the vestibular nerves (37.5%). AC in the fundus (Fig. 6A,B) displaced and compressed vestibular nerves in four patients, and the cochlear and facial nerves in two patients. Nerve displacement was observed in six patients (50% of AC in this location); cochlear-facial nerves were displaced in four patients versus vestibular nerves in two patients.

### Sagittal View Analysis

In 18 patients (75% of patients with arachnoid cyst), the arachnoid cyst was located centrally in the bundle (Figs. 7 and 8), in the PA in 2 patients (50% of ACs in the PA), in the middle part of the IAC in 6 patients (75% of ACs in this part of the IAC), and in the fundus of the IAC in 10 patients (83.3% of ACs in the fundus). In the remaining six patients, the arachnoid cyst was located laterally to the nerves (Figs. 7 and 8), and specifically in the PA in two patients, in the middle part of the IAC in two patients, and in the fundus in two patients (Fig. 8A).

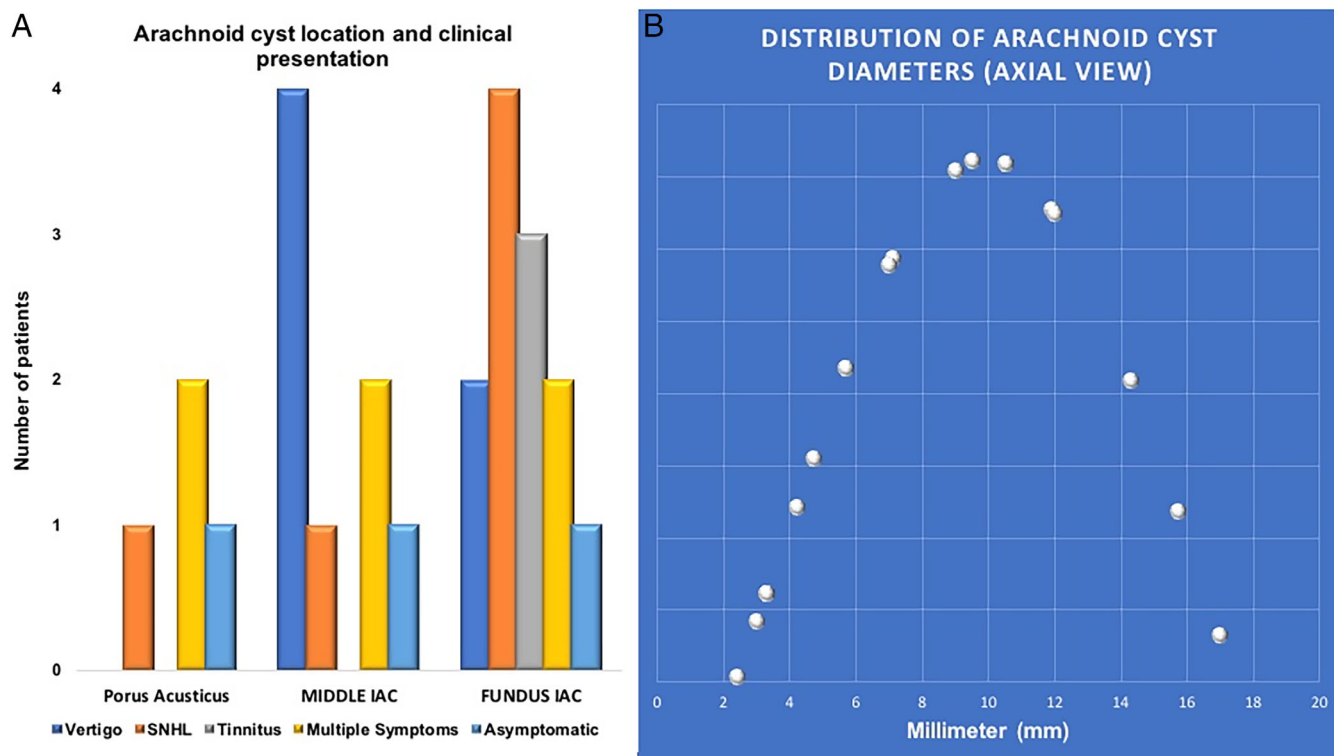


Fig. 5. Relationship of arachnoid cyst location and size to symptoms. A, Distribution of arachnoid cysts positions in relation to symptoms. B, Distribution of arachnoid cyst diameter; average arachnoid cyst diameter was 9.9 mm. [Color figure can be viewed in the online issue, which is available at [www.laryngoscope.com](http://www.laryngoscope.com).]

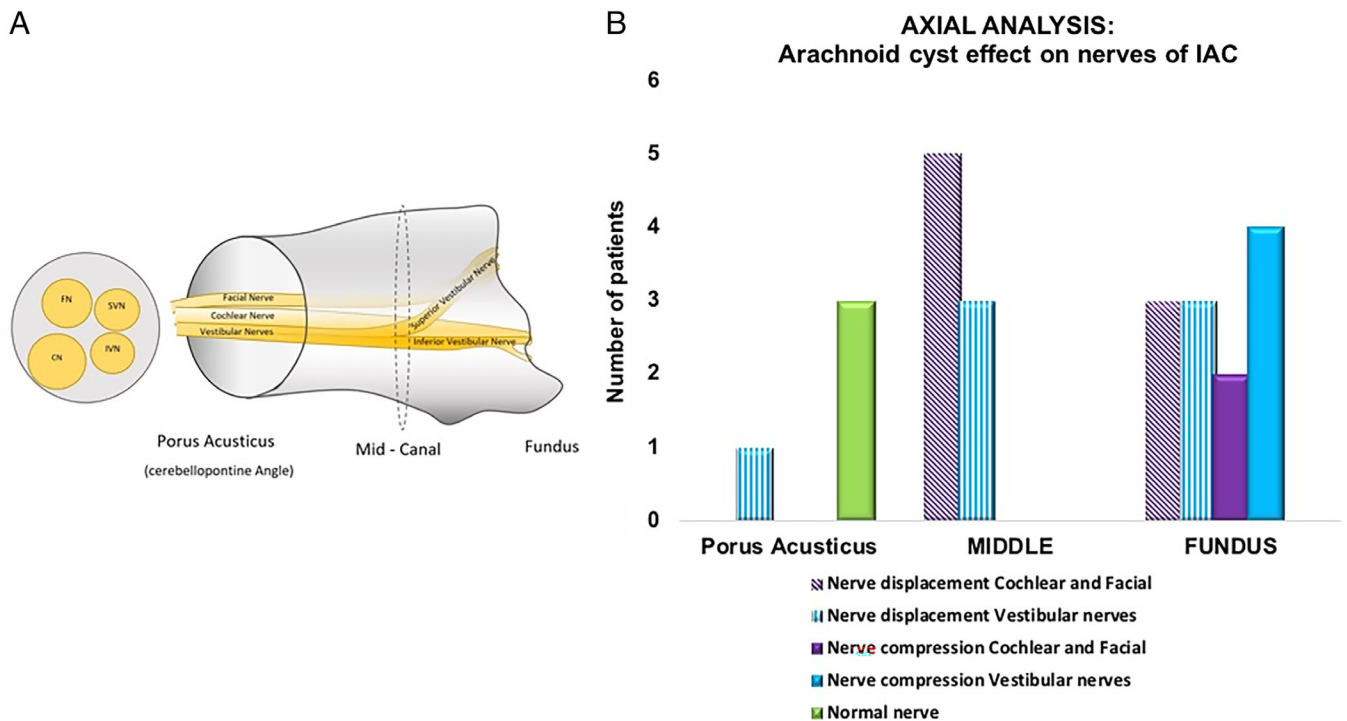


Fig. 6. Results of the axial views analysis. A) Schematic depicting course of cochlear nerve (CN), facial nerve (FN), superior vestibular nerve (SVN), and inferior vestibular nerve (IVN) traversing the internal auditory canal (IAC), with designation of the porus acusticus (PA), middle canal, and fundus regions, and cross-sectional view. B) The bar graph shows the number of patients with dislocated, compressed, or normal nerves as a function of arachnoid cyst location in the IAC (PA, middle, or fundus). The nerves pairs (facial/cochlear nerves or superior/inferior vestibular nerves) that were dislocated or compressed by the arachnoid cysts are shown. In the data set, all normal nerves were located in the PA. [Color figure can be viewed in the online issue, which is available at [www.laryngoscope.com](http://www.laryngoscope.com).]

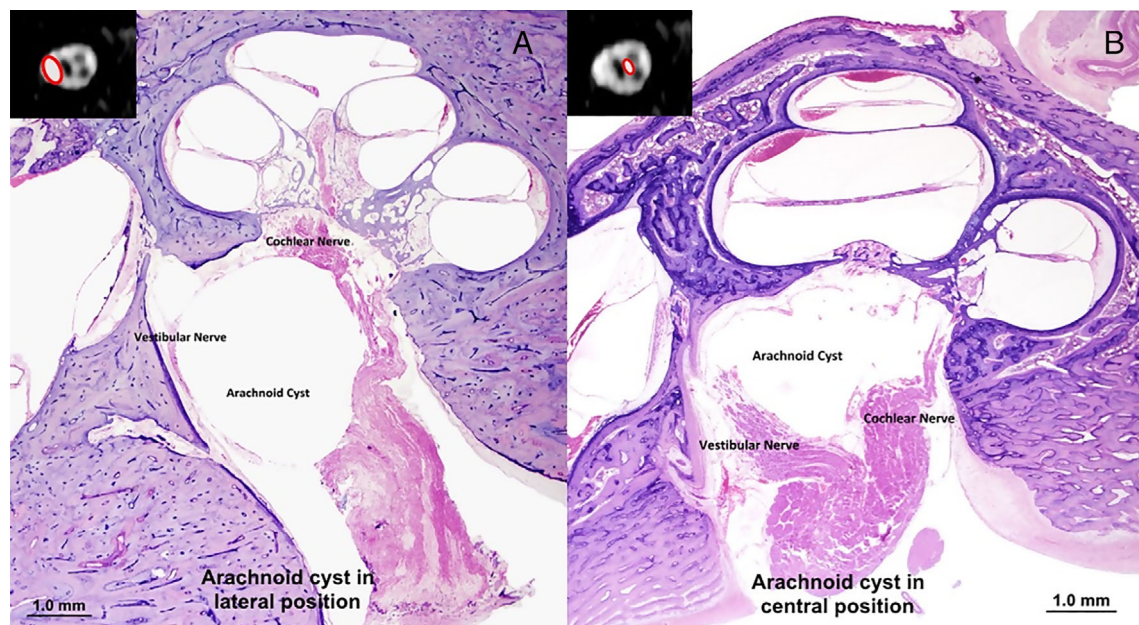


Fig. 7. magnetic resonance imaging of the internal auditory canal and human temporal bone demonstrating position of arachnoid cyst relative to the nerve bundle and associated displacement or compression. A, Cyst located laterally to the nerve bundle, compressing the vestibular nerve and displacing the cochlear nerve. B, Arachnoid cyst situated centrally in the bundle, displacing the cochlear and vestibular nerves without compression. [Color figure can be viewed in the online issue, which is available at [www.laryngoscope.com](http://www.laryngoscope.com).]

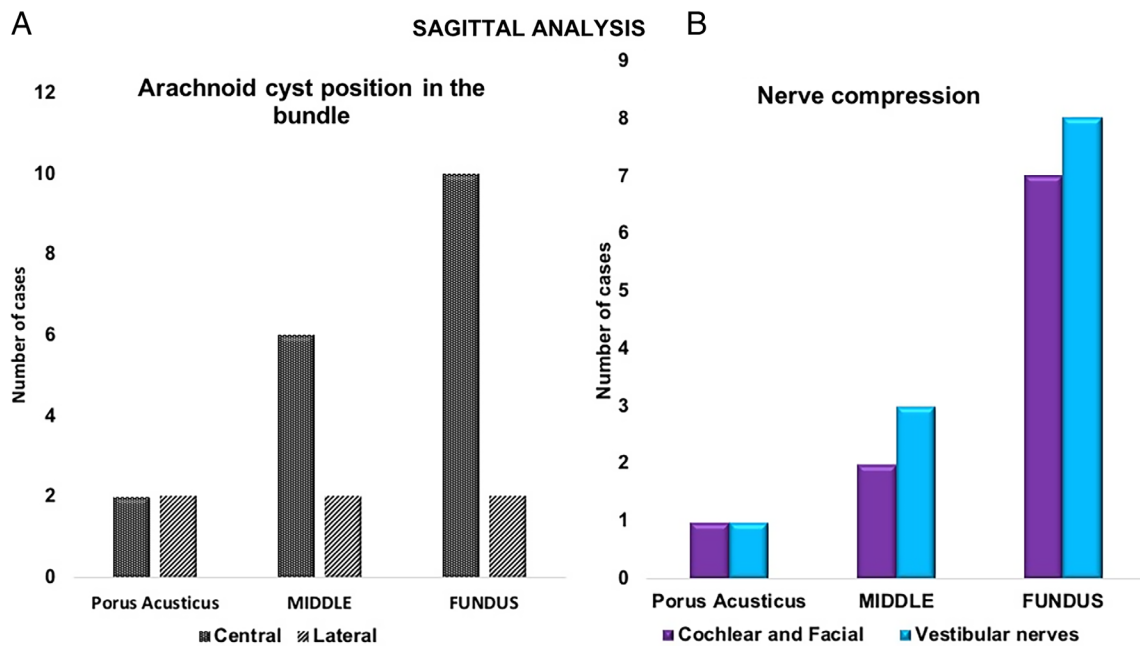


Fig. 8. Sagittal views analyses. A, Number of patients with arachnoid cysts located centrally versus laterally, as a function of arachnoid cysts location in the internal auditory canal (IAC) (PA, middle, or fundus); B, Number of patients with compressed nerves as a function of arachnoid cyst location in the IAC (PA, middle, or fundus). Calculations reflect nerve-paired facial/cochlear or paired superior/inferior vestibular nerves. [Color figure can be viewed in the online issue, which is available at [www.laryngoscope.com](http://www.laryngoscope.com).]

Analysis of nerve shape on sagittal views demonstrated findings consistent with nerve compression (Fig. 4B) in 21 patients, including 10 cochlear and facial nerves and 11 vestibular nerves (Fig. 8B), whereas no sign of nerve compression (round-shaped nerve) was observed in three patients (Fig. 8A). Sagittal view analysis detected more instances of nerve compression than axial analysis (21 vs. 6). When the cochlear nerve was compressed, the facial nerve was invariably compressed as well (and vice versa); likewise, a compression of one vestibular nerve always involved a compression of the other vestibular nerve, possibly related to the size of AC in our data set.<sup>3</sup> Statistical analysis on association between nerve compression and symptoms used paired nerves.

### Symptoms in Relation to Arachnoid Cyst Radiological Findings

Among the 24 patients with arachnoid cyst of the IAC, 21 patients reported one or more symptoms ipsilateral to the lesion (Fig. 9). The breakdown of symptoms included SNHL in 6 patients (25%), vertigo in 6 patients (25%), tinnitus (12.5%) in 3 patients, vertigo and SNHL in 2 patients (8.3%), vertigo and ataxia in 1 patient (4.2%), tinnitus and vertigo in 2 patients (8.3%), and tinnitus and SNHL in 1 patient (4.2%) (Fig. 5A). Two patients had auditory or vestibular symptoms on the side contralateral to the AC, and one patient had no symptoms (despite having a bilateral arachnoid cyst).

Among the four patients with AC in the PA, two patients had multiple symptoms, one patient had no symptoms, and one patient had SNHL. Among the eight patients with AC in the middle of the IAC, four patients had vertigo, two patients had multiple symptoms, one had SNHL, and

one had no symptoms. Among the 12 patients with AC in the fundus of the IAC, 4 patients had SNHL, 3 patients had tinnitus, 2 patients had vertigo, 2 patients had multiple symptoms, and 1 patient had no symptoms (Fig. 5A).

Presence of arachnoid cyst was strongly associated with symptoms reported on the ipsilateral side ( $\chi^2$ :  $P = .002$ ); larger arachnoid cyst diameter also was associated with symptoms (PBC:  $P = .02$ ) (Fig. 5A). Furthermore, position of AC in the IAC was associated with symptoms ( $\chi^2$ :  $P = .002$ ). AC were most commonly symptomatic when situated in the fundus and middle part of the IAC (Fig. 5).

### Comparison Between Axial and Sagittal Views Analysis Outcomes

Analysis of axial views demonstrated nerve displacement and compression in 6 out of the 24 arachnoid cases (25%), and in all these cases the AC were located in the fundus of the IAC (Fig. 8). Analysis of sagittal views demonstrated nerve compression (oval or rectangular shaped nerve) and displacement (increased distance between nerves or nerve position change as assessed from patient contralateral side) in 21 out of the 24 AC (87.5%). This difference in analysis outcome was significant ( $\chi^2$ :  $P = .003$ ).

### Correlation Between Nerve Compression and Symptoms

Radiological findings of compression of vestibular nerves was strongly associated with symptoms of vertigo (Spearman:  $P = .0001$ ). Similarly, compression of cochlear and facial nerves was strongly associated with auditory symptoms (SNHL and tinnitus) (Spearman:  $P < .0001$ ).

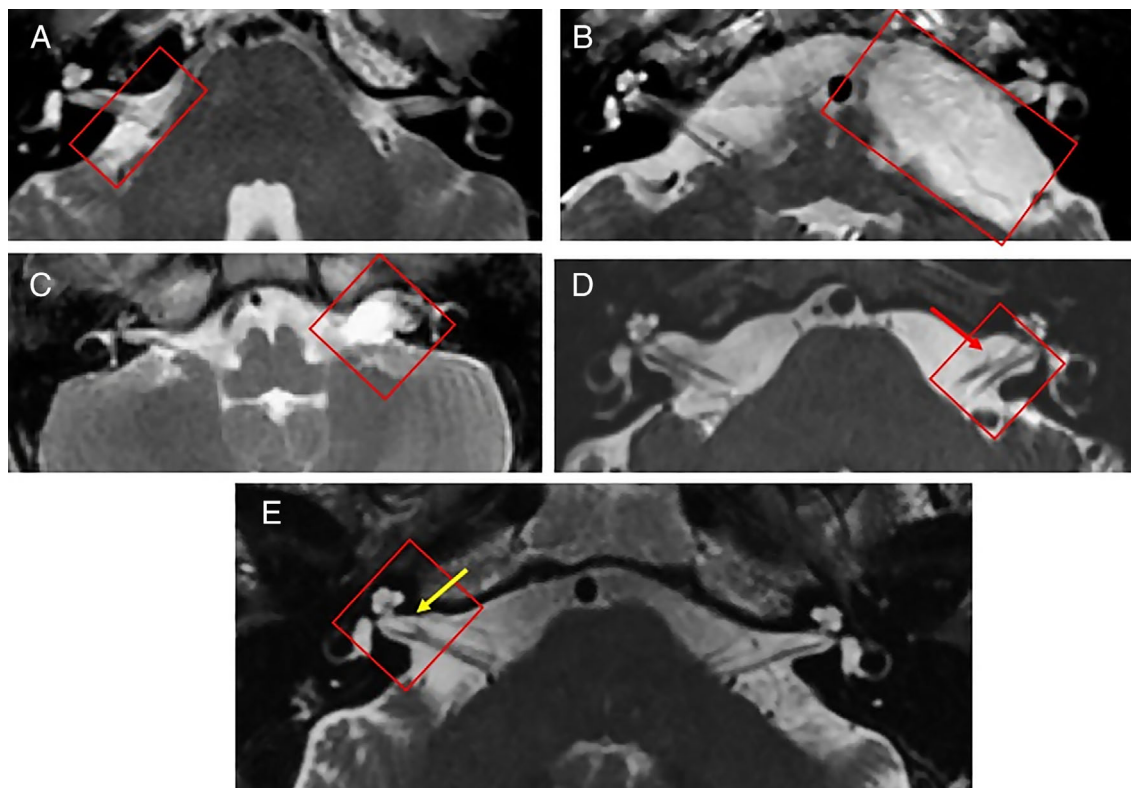


Fig. 9. Axial view of the cysts in the different areas of the internal auditory canal (IAC). The red box shows the cyst. A, Cyst in the porus without nerve displacement and compression. B, Large cyst in the porus which compresses the nerve in the IAC. C, Large cyst in the middle of the IAC that displaces and compresses the nerves (red arrow). D, Cyst in the superior-middle portion of the IAC, which displaces and slightly compresses cochlear nerve (yellow arrow). E, Cyst of the fundus displacing both nerves and compressing the cochlear nerve. [Color figure can be viewed in the online issue, which is available at [www.laryngoscope.com](http://www.laryngoscope.com).]

There was also an association between compression of cochlear and facial nerves and multiple symptoms (Spearman:  $P = .01$ ), but no statistically significant association between compression of vestibular nerves and multiple symptoms (Spearman:  $P = .08$ ).

## DISCUSSION

Although little is known about the history of AC of the IAC with or without intervention, the present study finds strong correlation between compression and ipsilateral symptoms. Our series identified AC with a prevalence of 1.9% (24/1247 cases reviewed), and of these patients less than half (10 patients) had a cyst in the fundus, confirming that a cyst in this part of the IAC is rare (Table S2). Most AC in the IAC are diagnosed during histological analysis of surgically removed tissue,<sup>18</sup> and differentiated from cystic schwannoma.<sup>19</sup> Prior studies on living patients with AC of the IAC are isolated case reports, mostly of a single case.

The best evidence on prevalence of AC of the IAC that was reported by Ungar and colleagues,<sup>4</sup> who identified 27 AC in 22 patients (5 bilateral cases), based on the analysis of histopathological section from the Massachusetts Eye and Ear Institute temporal bone library. The study included 624 males and 545 females (total 1167 cases). This finding of 27 cysts in 1167 patients is similar to the 24 AC of the IAC in 1247 patients in the present study, although

5 bilateral cysts in the prior study in contrast to only 1 bilateral case in our series. One third of the AC in that study were in patients with auditory or vestibular symptoms. We hypothesize that AC, although more compressible than solid tumors, may nonetheless induce impairment mediated by mass effect on nerve, causing ischemia, degeneration, or demyelination.

In the present study, use of MPR of T2-weighted MRI sequences facilitated detection and characterization of AC in the IAC, mirroring previous experience with this method in analysis of vascular loops of the IAC.<sup>16</sup> Axial views allow rapid screening for AC, measurement of cyst diameter, and localization within the IAC (PA, middle, or fundus). Sagittal slices improved detection of nerve compression. Of 1247 MRIs screened, 1.9% were verified as consistent with arachnoid cyst, and this result is consistent with previous evidence,<sup>20,21</sup> but our MPR-based analysis allowed us to appreciate more details about the effect that this entity could have on the surrounding structures that could explain patients' symptoms.<sup>16</sup> AC in the fundus or middle part of the IAC were more likely to be associated with symptoms compared to the PA,<sup>16,22</sup> consistent with the findings of Ungar et al.<sup>3</sup> Compression within the IAC<sup>16,23</sup> may thus predispose to auditory and vestibular symptoms,<sup>3,7</sup> and as IAC diameter decreases from PA to fundus, AC located centrally or laterally in the IAC (Figs. 2A and 6A) may be prone to cause a nerve compressive syndrome.<sup>7,16,23</sup>



AC of the IAC's were more likely to cause compressive findings in vestibular nerves than cochlear/ facial nerves;<sup>6,9,7</sup> but, vestibular and auditory symptoms had equal prevalence. This finding may reflect either differing levels of redundancy in hearing and vestibular systems<sup>24</sup> or central compensatory mechanisms.<sup>24</sup> In the auditory system, normal function requires intact peripheral and central auditory systems,<sup>24</sup> with subtle nerve insults causing tinnitus or mild SNHL.<sup>18</sup> Deficits of the vestibular system function may be compensated by the muscular and ocular systems, which work synergistically with the vestibular system to control balance and posture.<sup>23,24</sup>

Study limitations included cross-sectional design, and case selection. None of the 24 patients with AC underwent surgical intervention, and thus associations between symptoms and radiological findings are hypothesis generating; future work may aim to establish causality by direct observation of pathology and demonstration of reversal of symptoms with intervention. While previously reported anecdotally by the authors,<sup>21</sup> larger prospective data are needed. Also, MRI of the IAC's were only analyzed in patients with asymmetric cochlear-vestibular symptoms, and the rate of IAC AC in the general population remains unknown. Also, higher Telsa MRIs may allow enhanced resolution and detection, which is a consideration in this study as well as future investigations. Last, we classified nerve compression as present or absent although there is a gradient of nerve injury associated with compression; in a larger series, regression analysis could potentially delineate an association between degree of nerve compression and severity of clinical impairment.

Although many questions remain regarding the pathogenesis, natural history, and management of AC of the IAC, the data from this study contribute to our understanding and highlight promising future directions for research on this entity, as well as other uncommon lesions of the IAC.<sup>25</sup> Future studies are needed to replicate findings of this study in other patient populations and potentially with surgical correlates, when clinically indicated. The development of software for MRI allowing automated segmentation and extraction of features of lesions of the IACs will facilitate analysis and evidence-based therapeutic approaches. Furthermore, the development and expansion of national registries, in otolaryngology, neurosurgery, or neurology may allow for future studies involving larger samples. A long-term goal is prospective identification and tracking of patients to better define the natural history of AC of the IAC and outcomes of patients undergoing different treatments, such as fenestration or surgical removal and the role for multidisciplinary approaches.

## CONCLUSIONS

MRI-MPR of T2-weighted sequences can detect arachnoid cyst of the IAC and characterize compressive effects on the nerves bundle. MRI-MPR is a compelling option when gadolinium is contraindicated, for example, in patients with allergic reactions.<sup>14</sup> The finding that auditory and vestibular symptoms are associated with nerve compression highlights the need for further

research, which may inform diagnostic algorithms and decisions regarding surgical intervention or observation.

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